ABSTRACT

Soil nematodes are numerous in different ecosystems and form a major consumer group because of their abundance, high metabolic rate and diverse nature. They feed on the primary producer and soil microorganisms and their abundance indicate a close relationship between herbage and root production and decomposing organic substrate. Being inhabitants of interstices of soil they constitute an important pathway of energy flow and are probably responsible for a significant proportion of the below ground nutrient recycling. Plant parasitic nematodes show a direct relationship with losses in crop yield and the damage caused by them is insidious.

In the present investigation ecological studies on soil nematodes in tropical, irrigated upland and lowland crop fields of Sambalpur, India were made during the years 1986-1987. The area experiences a seasonal climate with heavy monsoon rain during mid June to September followed by mild winter and a very prominent long dry spell of summer extending from March to mid June. In this locality South-west monsoon brings abundant rainfall during mid June - September resulting in waterlogging situations of the arable crop fields. Rice is grown suitably and economically in these fields. This crop
is known as the Kharif crop (winter rice) which is transplanted in August and harvested in November. Availability of continuous assured irrigation in the post South-west monsoon period is also suitable for growing rice in the same fields. This crop is known as the Rabi crop (summer rice) extending from February to May. Thus rice (Oryza sativa L.) is cultivated twice a year and a constant water height is maintained throughout the cropping periods for the healthy growth of the rice plants and higher yield. The dynamics of root system and root input are more in these fields and the soil animal communities in such arable fields are thus exposed to various disturbances associated with the management practices like soil cultivation and harvest. The soil is sandy loam type in both the study plots. The upland site is 150 m apart from the lowland site with an elevation of around 5.5 m. A water height of around 8 cm in the lowland was recorded which was almost three times more than in the upland during Rabi crop and the water height was still more during Kharif crop.

Sixteen species of soil nematodes were identified of which fourteen species were found in the upland and ten species in the lowland rice field. The plant feeders were the most abundant group and Hirschmanniella mucronata was the dominant plant
feeding species recorded from every sample throughout the year in both sites. The species diversity of the plant feeding forms was observed in both the plots. Thus seven species were recorded from the upland rice field while five species from the lowland rice field. Acrobeloides sp. was the dominant microbivore species both in the upland and lowland rice fields. Among the miscellaneous feeders the Dorylaimus sp. was recorded from both the sites. Mononchus sp. was the dominant predator in both the upland and lowland rice fields. The index of similarity between the two sites was 0.66 for all the taxa but 0.50 for only the plant feeders. The mean annual importance value (IV) for the upland and lowland sites were 52.39, 30.91 for the plant feeders, 23.30, 28.48 for the miscellaneous feeders, 20.46, 36.76 for the predators and 3.83, 3.86 for the microbivores, respectively. The Shannon index of general diversity (H) value was more during May in the upland (1.24) and during March in the lowland (1.23). The narrow range of Shannon index of general diversity indicated a stable community at both the study sites.

Total number of nematodes decreased with increased soil depth. In the upland rice field the total nematode population density ranged from 6.53 to 67.83 x 10^4 m^-2 in the 0 - 10 cm soil layer and these were 72 to 82 percent of the total nematodes during the minimum
and peak period of density, respectively. Similarly, in the lowland rice field the nematode population ranged from $1.23 \times 10^4$ to $5.06 \times 10^4$ m$^{-2}$ in the 0 - 10 cm soil layer and these were 79 to 70 percent of the total nematodes, respectively in the mentioned period. Percent shares of various nematode trophic groups were different in the study sites. The plant feeders were more abundant in the 0 - 10 cm soil layer because of the shallow rooting system of the rice plant. The microbivores were much less possibly due to waterlogging and were more frequent in the top 5 cm of the soil in both the sites and were appreciably less in the deeper soil layers. The miscellaneous feeder and predator densities were more in the 5 cm surface soil in both the sites and decreased gradually with depth.

Marked seasonal changes in nematode density were observed for both the study plots. The mean nematode population density figures were 52.74, $5.85 \times 10^4$ m$^{-2}$ in winter and these declined to 14.10, $2.09 \times 10^4$ m$^{-2}$ in summer after which there was rise during rainy season to 31.87, $2.62 \times 10^4$ m$^{-2}$ in the upland and lowland rice fields, respectively. Considering different crops the figures for peak nematode population density were 19.62, $2.84 \times 10^4$ m$^{-2}$ in Rabi crop and 47.21, $3.66 \times 10^4$ m$^{-2}$ in Kharif crop in the upland and lowland sites, respectively. In both the sites nematode population increased throughout the rainy season to reach a November peak in the upland and December peak in the
lowland and then declined to reach the minimum in April.
Peak density of $80.47 \pm 7.82$ and $6.16 \pm 0.53 \times 10^4$ m$^{-2}$
and minimum density of $9.01 \pm 0.83$ and $1.66 \pm 0.45 \times$
$10^4$ m$^{-2}$ were observed in the upland and lowland sites,
respectively. The mean total nematode number for whole
of the sampling period in the 0 - 20 cm soil depth was
significantly higher in the upland than in the lowland
rice field ($t = 6.04$, $p < 0.001$).

Since soil nematodes are considered as both
primary and secondary consumers, seasonal dynamics of
vegetation biomass and primary production were also
determined for both the crop fields during January to
December, 1986. The vegetation showed a period of
maximum biomass in November for Kharif crop and in May
for Rabi crop. Net primary productions were 2191 and
1731 g dry mass m$^{-2}$ during Rabi crop and Kharif crop,
respectively in the upland. These values in the lowland
were 1372 and 1918 g dry mass m$^{-2}$ in the mentioned
order. Daily growth rate was estimated to be around
23.5 and 14.7 g dry mass m$^{-2}$ for total vegetation, 20.3
and 12.9 g dry mass m$^{-2}$ for above ground vegetation,
3.2. and 1.8 g dry mass m$^{-2}$ for below ground vegetation
during Rabi crop in the upland and lowland sites,
respectively. Likewise daily growth rate values were
18.4 and 20.4; 16.8 and 18.7; 1.5 and 1.6 g dry mass m$^{-2}$
for the upland and lowland rice fields during Kharif
crop in the mentioned order. The dead roots and stubbles
constituted the mulched material and were 559, 819 g dry mass m$^{-2}$ in the upland and 408, 465 g dry mass m$^{-2}$ in the lowland during Rabi and Kharif crop, respectively. These materials disappeared at the rate of more than 70 percent during Kharif crop and 40 percent during Rabi crop.

The average dry mass for plant feeders, microbivores, miscellaneous feeders and predators were 0.093, 0.053, 0.378, 0.195 $\mu$g and 0.093, 0.053, 0.264, 0.241 $\mu$g for the upland and lowland sites, respectively. The mean individual nematode dry mass was 0.170 $\mu$g for the upland and 0.163 $\mu$g for the lowland site. The mean monthly biomass with standard deviation for the upland was 43.24 ± 9.10 mg dry mass m$^{-2}$ with a turnover of 4.7 and for the lowland 5.41 ± 2.67 mg dry mass m$^{-2}$ with a turnover of 3.8 during the period of study. The secondary nematode production values were 58.35, 90.57, 251.65 mg dry mass m$^{-2}$ for the upland and 5.81, 9.96, 24.30 mg dry mass m$^{-2}$ for the lowland for Rabi crop, Kharif crop and whole of the year, respectively.

Vegetation biomass, soil moisture and soil temperature played important role in regulating the nematode biomass. Nematode biomass showed a significant negative correlation with temperature, negative correlation with soil moisture and positive correlation with relative humidity in both the sites during Rabi crop.
Kharif crop and also for the whole of the year. Significant positive correlation between nematode biomass and various components of vegetation both in the upland and lowland rice fields during Kharif crop indicated their close dependence. Temperature, soil moisture and vegetation cover are the key factors in regulating nematode abundance but temperature seems to be more important also in tropical soils as the nematode biomass increased during winter Kharif crop with low temperature, moderate moisture and vegetation growth but declined in the summer Rabi crop when temperature increased while the other two factors remained the same as that during Kharif crop.

The rhizosphere effect of rice on soil nematodes, percent organic matter and percent total nitrogen was studied in the upland site during February to July, 1986. The proportion of plant feeders and microbivores was considerably higher than that of miscellaneous feeders and predators in the rhizosphere soil compared to root-free soil. Nematode population in the rhizosphere soil reached a peak of 271 ind. 100 g⁻¹ dry soil in March, week II. Nematode density, percent organic matter and percent total nitrogen were significantly more in the rhizosphere soil than in the non rhizosphere soil. In the rhizosphere soil nematode abundance showed a significant positive correlation with percent organic matter ($r = + 0.49, p \leq 0.1$) and
percent total nitrogen ($r = + 0.55$, $p < 0.1$) indicating an increase in the density of microorganisms and soil nematodes by the root exudates and decomposing roots.

The present study deals with the dynamics of different trophic groups and of total nematode community in upland irrigated arable soil under rice, wheat, green gram and fallow during summer Rabi crop (January - April, 1987) following Kharif crop (August - November, 1986) of rice.

In the beginning of the study, during January, 1987, there were no significant differences in the total nematode numbers between the cropping plots and the mean total number was within the range of $20.84 \times 10^4 \, m^{-2}$ (fallow) to $30.04 \times 10^4 \, m^{-2}$ (wheat). The nematode population increased with the growth of the crop plants and the mean number of the nematodes during the peak period in March, week II was highest $68.45 \succ 53.93 \succ 39.32 \succ 34.07 \times 10^4 \, m^{-2}$ in wheat, green gram, rice and fallow plots, respectively. Statistical differences between mean plant feeder and miscellaneous feeder number was observed ($p \lesssim 0.005$) between rice and wheat; wheat and fallow; green gram and fallow but such differences for microbivores and predators were not observed during the period of study. On an average the proportion of plant feeders was the highest and the range was from 60 percent in fallow to 70 percent in wheat.
Of the different plant feeders five taxa (genera) were dominant in the cropping plots during the study period. *Helicotylenchus* sp. was especially abundant in green gram and fallow plots whereas *Hirschmanniella* sp. dominated in rice and wheat plots. Percentage contribution of *Helicotylenchus* sp. in rice plot was 35 and in wheat plot 26 percent of the total plant feeders present. The other plant feeding taxa were less numerous than the above two genera in all the cropping plots during the period of study indicating non-specific preference for plant roots.

The index of dominance (c) for the four cropping systems basing on the contribution of each taxa to the total plant feeder population decreased in the order of 0.434 (in rice indicating more dominance), 0.399 (green gram), 0.381 (wheat) and 0.360 (fallow) being the lowest.

The build up index (Pf/Pi) of *Hirschmanniella* sp. was more in rice and wheat being 2.21 and 2.17 respectively. Maximum index value for other taxa in different crops were: *Helicotylenchus* sp. 3.45 in green gram, *Meloidogyne* sp. 3.56 in wheat, *Tylencholaimus* sp. 4.96 in green gram and *Tylenchorhynchus* sp. 3.58 in wheat.

The effect of Thimet 10-G, an organophosphorus systemic insecticide, on the distribution and population dynamics of soil nematodes in the irrigated upland rice
field was studied during winter Kharif crop of rice in 1986. Thimet 10-G was broadcast uniformly at the minimum certified agricultural dose (4.5 kg acre$^{-1}$) in August, week IV to the experimental plot and was repeated after 45 days as recommended. A laboratory study was also performed with multiples of certified agricultural dose for the proper management of this agrochemical and to determine its effect on other non-target soil nematodes. Experiments in the laboratory were conducted in polythene bags using the surface area for calculation of equivalent/-acre dose of the insecticide.

The nematode population of the control and experimental plots were almost identical prior to insecticide broadcast. This population soon after first broadcast increased from 13 to 35 percent (3 times) in the experimental plot. After the second broadcast the nematode population decreased by 15 to 31 percent till the end of the experiment. The insecticide enhanced and decreased the number of plant feeders after the first and second broadcast, respectively. The microbivores, miscellaneous feeders and predators decreased after the broadcasts. The difference in nematode population in various soil layers between control and experimental plots (lower population in 0 - 10 cm and higher population in 10 - 20 cm soil layer in the experimental plot than the control plot) clearly indicate the influence
of the applied insecticide exhibiting vertical migration. This migration into the deeper soil layer is more by the plant feeders followed by the predators.

In the laboratory experiments there was no marked difference in nematode number between the control and single dose treated set till the third week but the difference was well marked for rest of the study period and for other treated dose sets. The effect of insecticide on total nematode population showed a significant difference (p < 0.005) between single and double dose, double and tetra dose sets. ANOVA shows that the population variation of different trophic groups and total nematodes is highly significant with different doses of insecticide treatment.